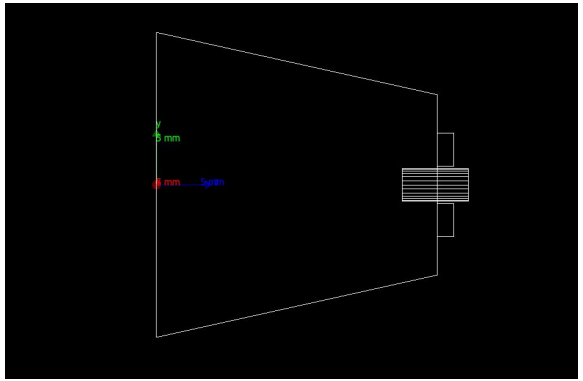
Lightguide Simulation Update: 25 October

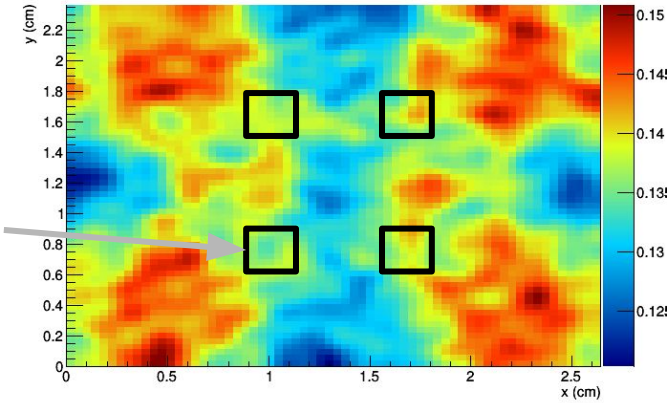
Michael Phipps

Notice a difference??? … Problem fixed!?

Before

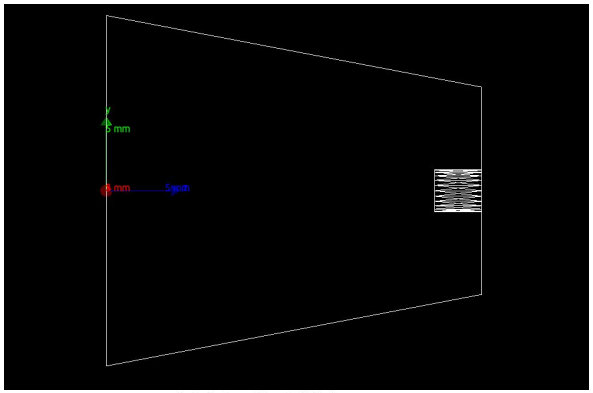


Lightguide Efficiency

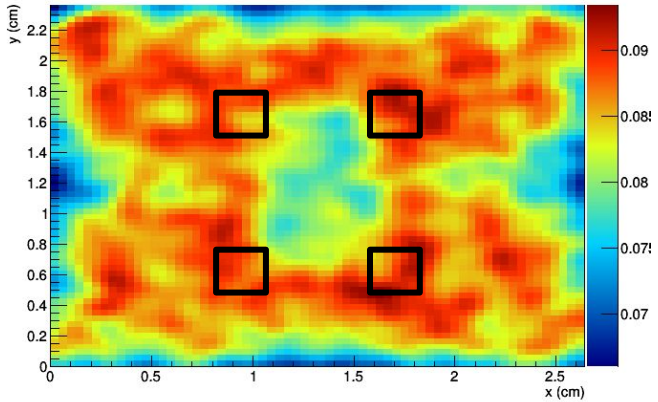


SIPMs

After



Lightguide Efficiency

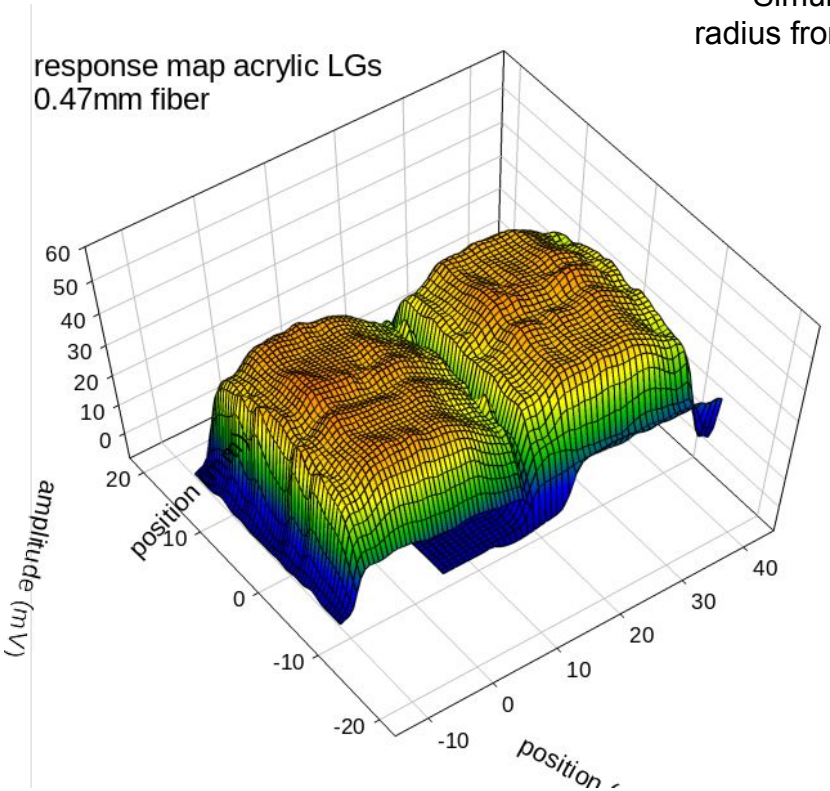


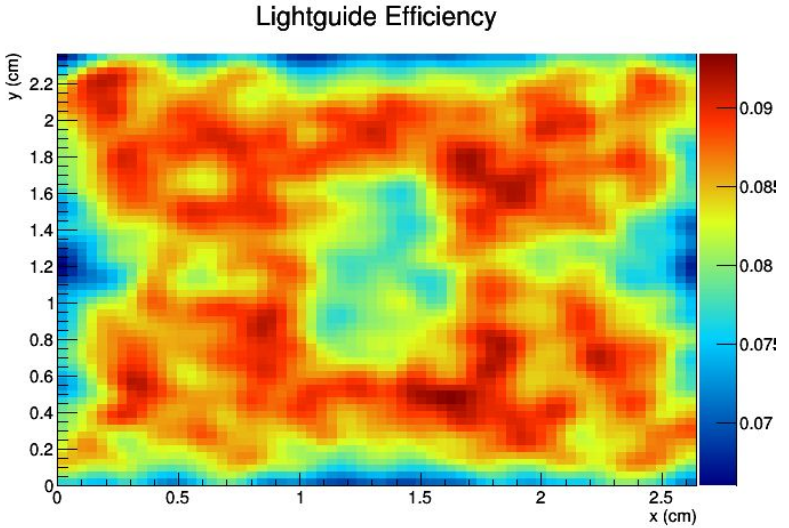
Efficiency scan of polished 2.54 cm tall lightguide

Measured (Sean)

**** Simulation scan stops a fiber's radius from edge

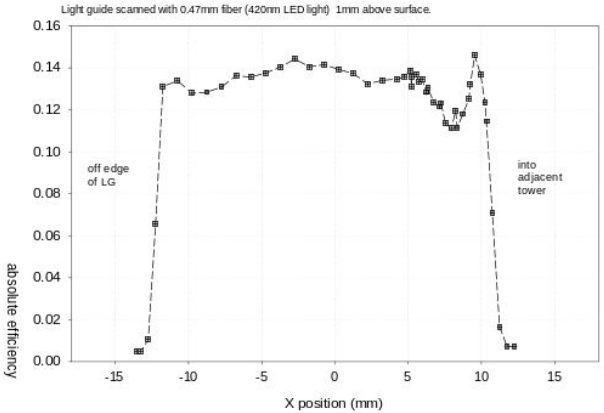
Simulated

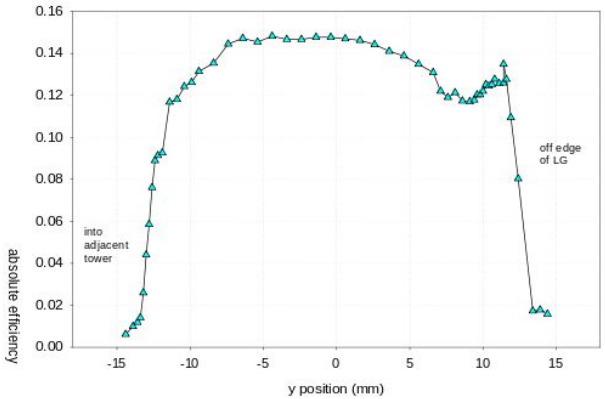




Efficiency Projections

Measured (Sean)

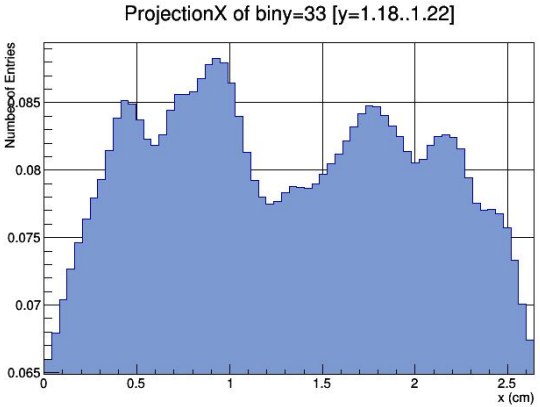


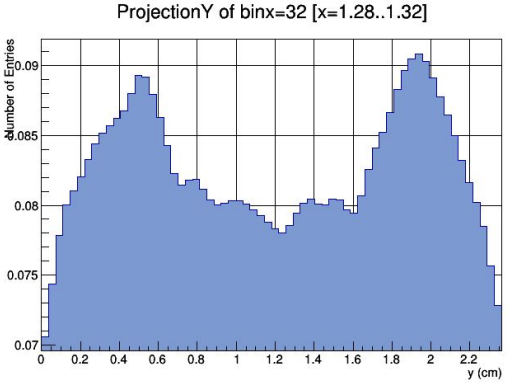


**** Efficiency of simulation a little off

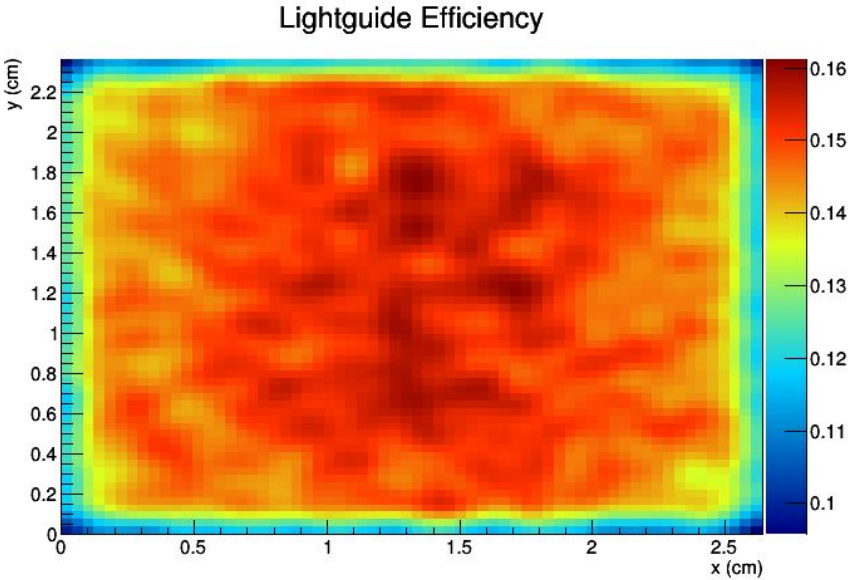
**** Dip in center corresponds to screw

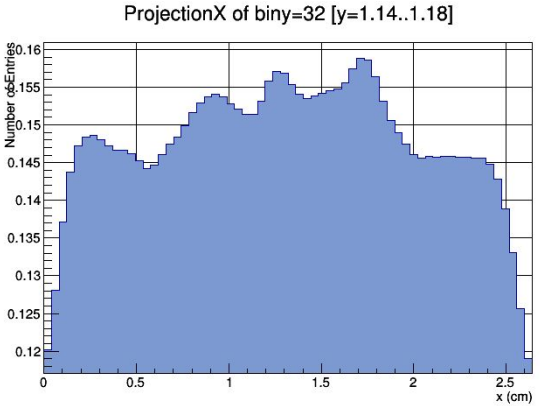
Simulated

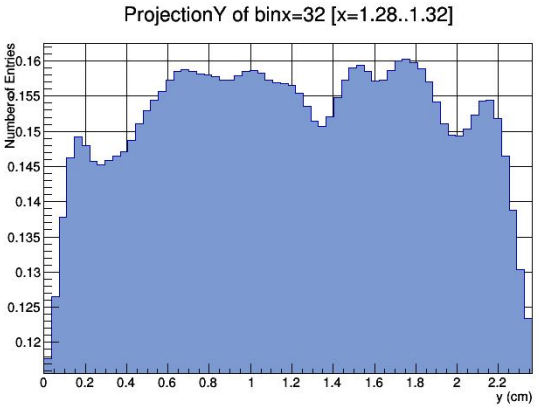




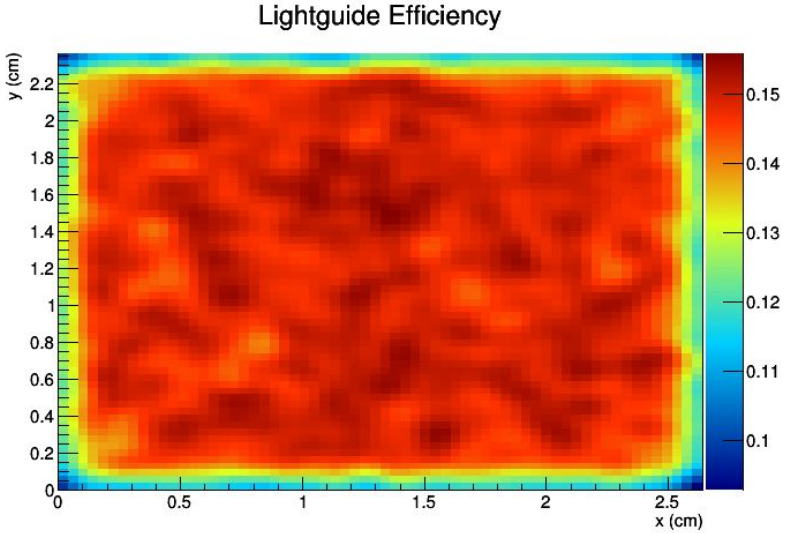
Efficiency scan of polished 5 cm lightguide (~2x original)

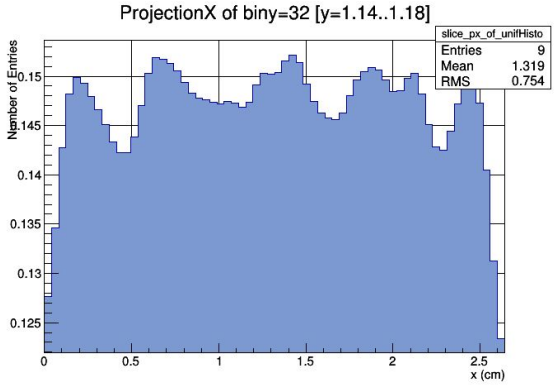


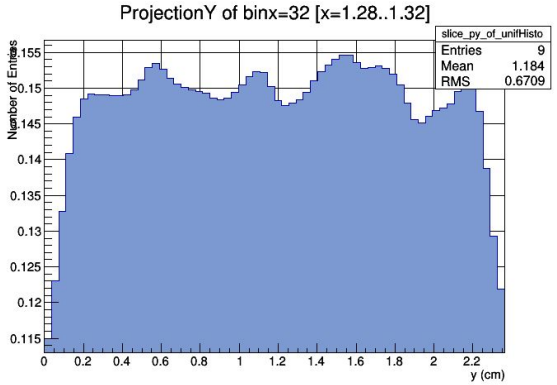




Efficiency scan of polished 3.75 cm lightguide (~1.5x original)





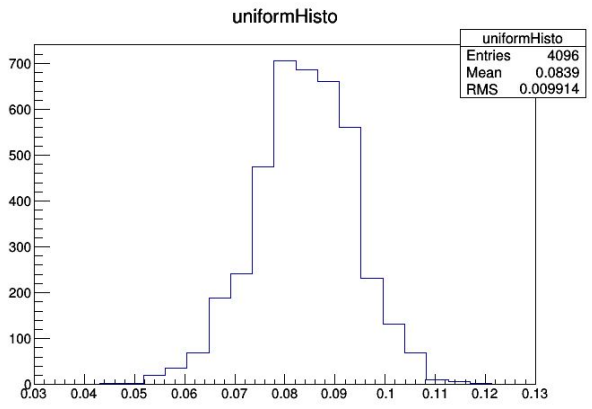


**** 3.75 mm lightguide more uniform than 5 mm lightguide!!!

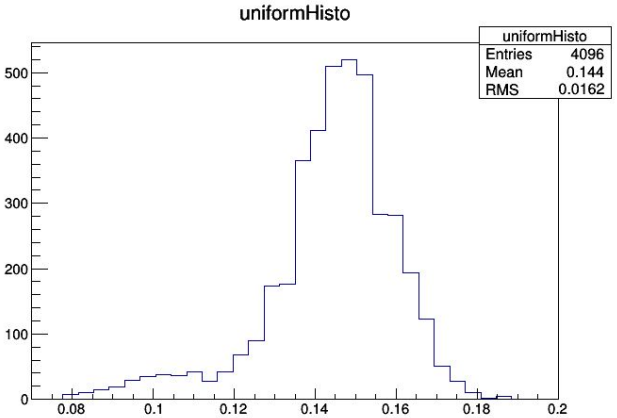
**** Not surprising if you consider the limit as the height increases -- most likely event is in the center of the lightguide (between the 4 SiPMs)

Lightguide uniformity

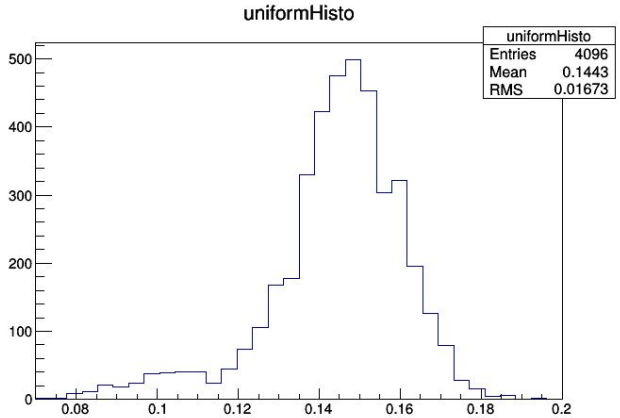
2.54 mm Height



3.75 mm Height



5.0 mm Height



Extras

Method

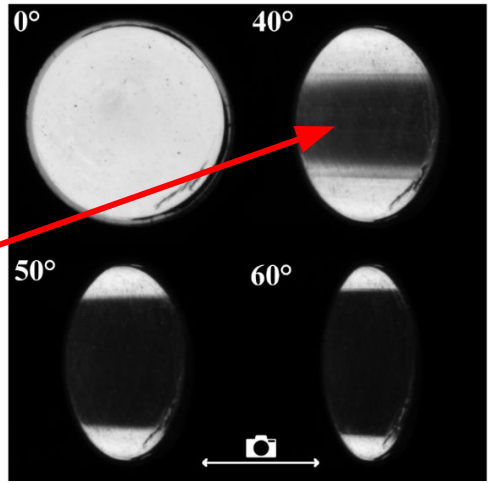
- Geant4 scan using 2.75 eV photons
- Optical photons emitted from 0.15 mm from wide end of lightguide
- Angular distribution: see slide 3
- Scan proceeds in even steps with 1k events per position and a 16x16 sample matrix
- Total efficiency defined as average hits/samples across entire scan
- Hit defined as any event with a photon entering an sipm. Hit receives a score of 1, all other events receive a 0
- Lightguide built with acrylic and refractive index of 1.49, absorption length of 26 m and reflectivity of 96% (Fresnel losses with polished lightguide). Boundary between lightguide and air defined as dielectric-dielectric
- Screw built with acrylic and given same optical properties as lightguide with coarse unpolished interface between the two
- Four 3x3 mm sipms flush against end of lightguide

Angular Distribution

- Particle gun placed along bottom edge of lightguide with angular emittance set using distribution below
- German Master's student did angular CCD scan and Geant4 simulations on emittance angles of single/multiclad lightguides, scintillating fibers and WLS
- Scanned Theta angle from 0-90 deg; intensity weighted at each point by the 2pi azimuthal solid angle
- http://web.physik.rwth-aachen.de/~hebbeker/theses/nieswand_master.pdf
- Numerical aperture of our fibers: 0.555 -> Max angle for meridional rays: $\sin^{-1}(NA) = 33.7^{o}$
- Distribution not exact for our fibers but approximate to first order

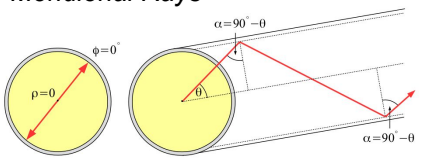
Beyond numerical aperture, only skew rays remain.

Higher angles -> rays closer to cladding

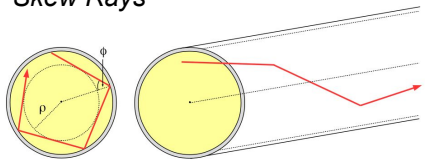


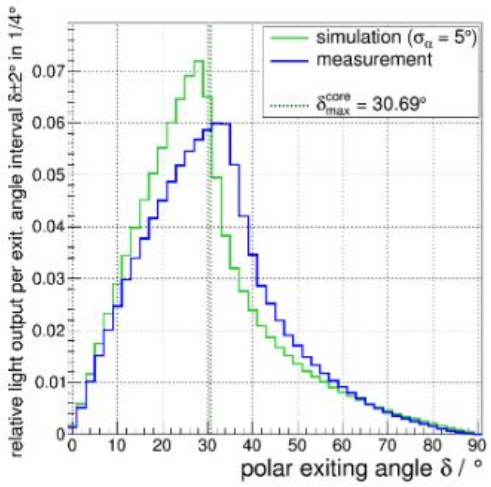
2 Types of Rays in Fibers:

Meridional Rays



Skew Rays





Sean's Measured Efficiency Scans